Space Weather Technical Forecast

Issued on Friday, 24 December 2021 at 01:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of G1/Minor Storm early Christmas Eve with CME arrival. Chance of R1/R2 blackout with slight chance R3 blackout. Active fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with numerous C-class flares observed. There are nine sunspot regions. AR2907 remains the most complex, and has been developing further as it approaches the southwest limb, and is currently classified as Fhi/beta-gamma. The other regions potentially capable of producing significant flares are; AR2916, which remains a large, stable region with an Eho/beta classification, along with regions AR2917 Dai/Beta and AR2918 Dsi/Beta in the eastern hemisphere. All other regions are small and magnetically simple.
No Earth-directed CMEs were observed in available imagery in the last 24 hours, although three are potentially on route, although confidence is very low in the latter two with only glancing impacts possible.

Solar Wind / Geomagnetic Activity: Solar winds speeds as measured by DSCOVR at L1 have remained at predominantly elevated levels, although with a gradually declining trend, from 585 km/s to near or just below 500 km/s, as Earth exits the recent fast wind enhancement from CH35. However, a data gap exists until 23/0310 UTC. The density was initially above average at 16 ppcc, then gradually decreased to average levels to end the day around 7 ppcc. Interplanetary magnetic field strength (IMF), Bt has been weak throughout, below 5 nT, with the north-south component, Bz varying from -3nT to +4nT. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) rose from mainly background levels to become High from 23/0920-2310 UTC, peaking at 2410 pfu at 23/1605 UTC. Towards the end of the day the electron flux bounced around close to or touching the 1000 pfu High threshold. The associated 24-hour integrated fluence started below the Active (1e8 integrated pfu) threshold, but steadily increased to breach the Active threshold at 23/2100 UTC, and with a fluence of 1.09e8 integrated pfu being recorded at 24/0000UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is expected to continue through the forecast period, with C-class flares expected, a chance (40%) of further M-class flares and a slight chance (10%) of an X-class.

Solar Wind / Geomagnetic Activity: There are three potentially Earth-directed CMEs. The first from an M-class flare from AR2908 on the 20th, expected to arrive early today (24th). The other two CME's are from the 21st (likely from the C4-flare of AR2809) and 22nd (from a further M-flare of 2808). These are are both very weak, and with low confidence, probably missing just ahead of Earth but could glance Earth on the 26th or 27th. Outside of potential CME influence the currently elevated solar winds are likely to to continue to gradually ease, as the effects of CH35 wane, until day 4 (27th) when a high speed stream (HSS) from CH37 is expected to arrive. Quiet to Unsettled (Kp 0-3) geomagnetic activity is generally expected with Active (Kp 4) intervals likely at times due to either CME arrival or HSS influence, with a chance of G1/Minor Storm (Kp 5) today and a slight chance on day 4.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels and below the S1 level, although there is a slight chance for some increased flux from any significant flare activity. High energy electron flux is currently at moderate levels, and is expected to drop to background levels with the CME arrival. However, later today the high energy electron flux is likely to increase again, as geomagnetic activity associated with the CME arrival wanes. There is a chance of High electron flux occurring later today, and then at the peak of the diurnal cycles through the rest of the forecast period. However, confidence is low regarding this. Electron fluence is currently at Active levels, but is expected to decrease below Active later today with the CME arrival, before probably returning to Active levels from late day 2 (Christmas Day).

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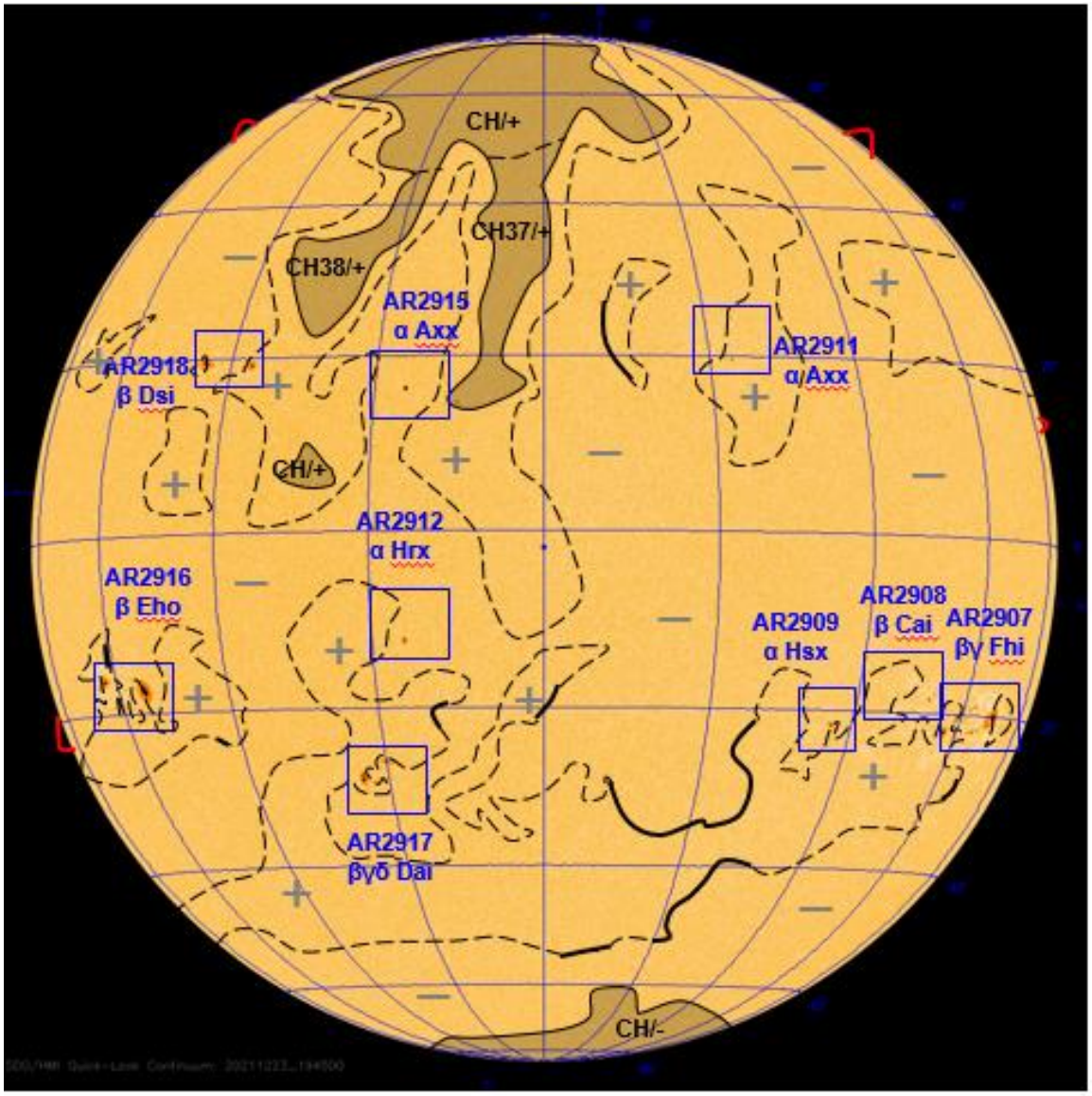
Figure 1. Solar Analysis Valid 23/1945 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

An Earth-directed CME which left the Sun on the 20th is anticipated to glance Earth early today (24th). There are two further CMEs of interest for the forecast. A CME which is visible on STEREO A, likely originating from either a filament eruption at around 21/1730 UTC in the southeast disc, or a C4 flare from AR2909 at 21/1914 UTC, or a combination of the two. A glancing influence from this CME is possible on Boxing Day (26th). A further very narrow CME occurred on the morning of the 22nd, perhaps associated with the M-flare of AR2908, could glance Earth on the 26th or 27th, but confidence is low regarding this.

Otherwise solar winds are currently easing after recent prolonged enhancement due to the fast wind of CH35, and in the absence of any CME enhancement would be expected to decline towards background through the period. The next coronal hole fast wind enhancement is likely to be from CH37, a southern extension of the northern crown, most likely on day 4 (27th), but with a slight chance of an earlier arrival on day 4 (26th).

Quiet to Unsettled (Kp 0-3) geomagnetic activity is generally expected with Active (Kp 4) intervals likely at times due to either CME arrival or HSS influence, with a chance of G1/Minor Storm (Kp 5) today and a slight chance on day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	5	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Name	Liftoff Time	Long	Lat	Radial Speed (km/s)	Half Angle	Time at 21.5Rs
CME-202112-012	20/12/2021 12:36	11E	14S	625	34	20/12/2021 18:04
CME-202112-015	21/12/2021 19:15	30W	20S	319	22	22/12/2021 07:26

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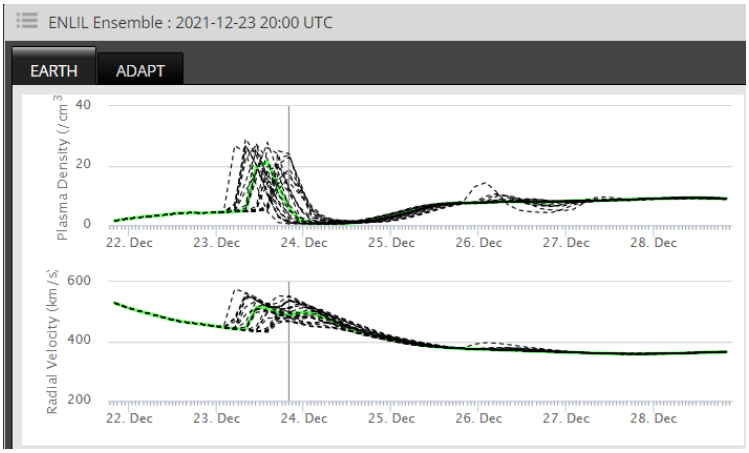
Figure 2: Met Office Enlil ensemble forecast.



Radio Blackouts - X-Ray Flares:

Despite the current nine active sunspot regions, solar activity has been Low.
There are nine sunspot regions. AR2907 remains the most complex, and has been developing further as it approaches the southwest limb, and is currently classified as Fhi/beta-gamma. The other regions potentially capable of producing significant flares are; AR2916, which remains a large, stable region with an Eho/beta classification, along with regions AR2917 Dai/Beta and AR2918 Dsi/Beta in the eastern hemisphere. All other regions are small and magnetically simple.

Low solar activity is expected to continue through the forecast period, with C-class flares expected, a chance (40%) of further M-class flares and a slight chance (10%) of an X-class. There are also a number of filaments in the southern hemisphere which, while currently stable, continue to be monitored.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	10	10	10	10

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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels and expected to persist at these levels. AR2907 is in a geoeffective location for proton storming, with this region having the greatest potential for generating a significant flare and a proton rich eruption.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as measured by GOES-16 at GEO exceeded the High (1e3pfu) threshold yesterday, but is currently at moderate levels. However, increased geomagnetic activity in association with a CME today (24th), is likely to lead to a redistribution of electrons within the radiation belts, potentially temporarily reducing flux levels to background levels for a while, although with low confidence. Later today and especially through tomorrow the high energy electron flux is likely to increase again, as geomagnetic activity associated with the CME arrival wanes. There is a chance of High electron flux occurring later today, and then at the peak of the diurnal cycles through the rest of the forecast period.

Electron fluence is currently at Active levels, but is expected to decrease below Active later today with the CME arrival, before probably returning to Active levels from late day 2 (Christmas Day). The REFM model is struggling to cope with the combination of CME arrival and then potential rebounding fluence, although the model does show the fluence starting above Active today and returning above Active for tomorrow. Thereafter confidence is low in the model.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	60	60	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 3: Met Office REFM model.

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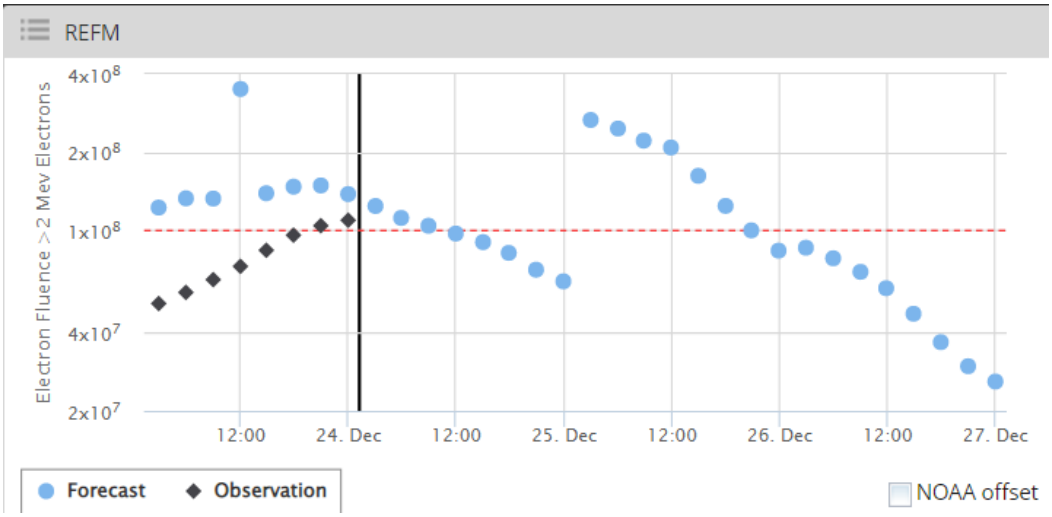

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